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THERMO-MECHANICAL TREATMENT OF HIGH SHEAR MELT-CONDITIONED TWIN ROLL CASTING STRIP OF RECYCLED ALUMINIUM ALLOYS

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INTRODUCTION

A continuous high shear melt conditioning twin roll casting process has been developed in BCAST for the production of Aluminium alloy strip with fine and uniform microstructure and minimal centre-line segregation. High shear melt conditioning is applied to increase the tolerance to high impurity levels in recycled Aluminium. The study have shown that by using intensive melt shearing immediately prior to casting, it is possible to control solidification during twin roll casting TRC, which can promote equiaxed growth with minimal defects, resulting in improved sheet quality. Melt conditioned twin roll cast (MC-TRC) of AA-5754 alloy exhibits a fine, equiaxed grain structure with reduced or completely eliminated centre line segregation. The thermo-mechanical treatment of melt conditioned twin roll cast strip shows a clear grain recrystallization at 430°C for 30 min with better mechanical properties than the conventional twin roll casting. MC-TRC with thermo-mechanical treatment could be used to increase the tolerance of Aluminium alloys to impurities typical of those that accumulate from the use of postconsumer scrap in the melt formulation. In this process, a rotor-stator device was employed for intensive shearing of the melt and integrated with TRC as shown in Figure 1.

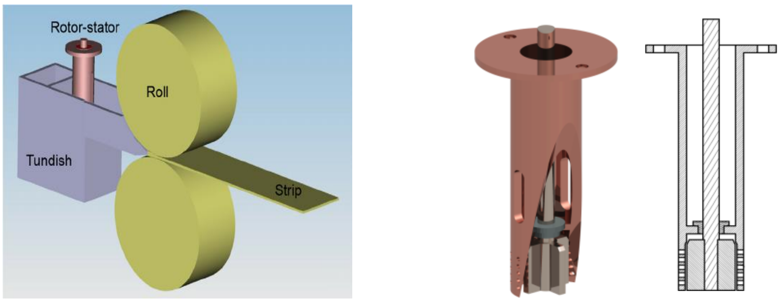

Figure 1. Schematic illustration of the MC-TRC process with the Rotor-Stator shearing device

The main advantages of the high shear Rotor-Stator device includes easy to handle, enhancement of kinetics for chemical reactions, homogenisation of chemical composition and temperature close to the solidification front and forced wetting of usually difficult to wet solid particles in the liquid metal. As a result, the high shear device can be used for physical grain refinement by fragmenting and dispersing naturally occurring oxides which can then act as heterogeneous nuclei and overcome the limitations of conventional twin roll casting. It is hoped that by incorporating intensive melt shearing TRC can produce a wider range of alloys and end products. For the first time, MC-TRC process was successfully used to produce high quality strip from AA-5754 scrap analogue alloys. MC-TRC strip shows fine grain structure and uniform composition with minimal segregation when compared to TRC process with improved formability. Nilam et al. (2016) demonstrated in their study that by using Rotor-Stator liquid intensive shearing for Al-3Mg, the MC-TRC strip at the final gauge exhibited 22% higher elongation compared with the TRC strip. The texture analysis revealed that more and uniform plastic deformation has occurred during MC-TRC than TRC as shown in Figure 2.

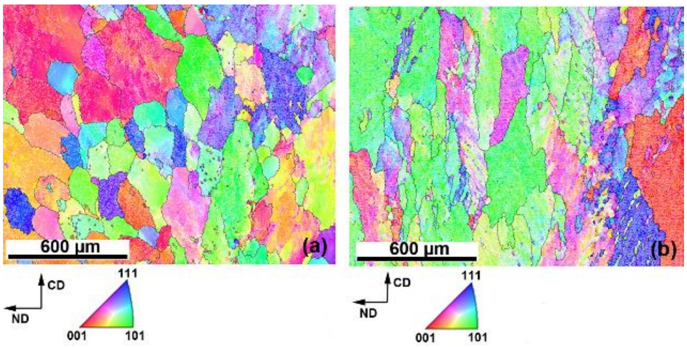

Figure 2. Inverse pole figures EBSD maps showing the grain structure of (a) TRC and (b) MC-TRC as-cast strips

Experiments were conducted to optimize the operating conditions such as pouring temperature, casting speed, setback for a certain roll gap for conventional TRC and melt conditioned MC-TRC of process scrap Aluminium alloy AA-5754 followed by thermo-mechanical treatment.

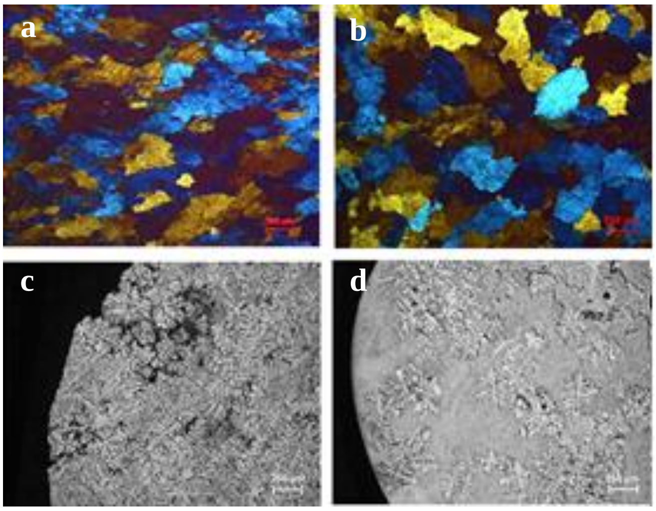

Figure 3. As cast AA5754 strip of: (a,c) conventional TRC, (b,d) MC-TRC at different magnifications

By using liquid intensive melt conditioning, it is possible to influence solidification during Twin Roll Casting, and promote equiaxed growth resulting in improved sheet quality and properties with minimal centre-line segregation as shown in Figure 3. The thermo-mechanical treatment of melt conditioned twin roll cast strip shows a clear grain recrystallization at 430°C for 30 min with better mechanical properties than the conventional twin roll casting.

REFERENCES

Barekar, N.S., Das, S., Yang, X., Huang, Y., ElFakir, O., Bhagurkar, Zhou, L. & Fan, Z. (2016). The impact of melt conditioning on microstructure, texture and ductility of twin roll cast aluminium alloy strips. *Materials Science and Engineering: A, 650*, 365–373. https://doi.org/10.1016/j.msea.2015.10.079

KEYWORDS

Deformation, Melt conditioning, Recycled Aluminium, Segregation, Thermo-mechanical treatment, Twin roll casting

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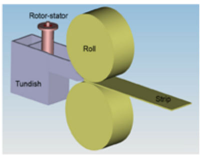
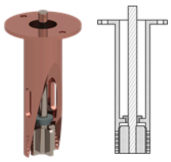
Introduction

In order to minimize defects in Twin Roll Casting (TRC) of aluminium alloys and improve the quality of the cast strip, a new technique that eliminates the addition of grain refiner into the melt prior to the casting has been investigated. It has been shown that, a fine and uniform microstructure can be achieved by melt conditioning using intensive melt shearing prior to casting. Intensive melt shearing, can cause the fragmentation of naturally occurring oxides in the liquid Al alloys and can enhance heterogeneous nucleation and bring about refinement of the grain size and intermetallic phases.





Experimental Procedure

Experiments were carried out using a shearing box and tundish/tip assembly made of N17 refractory board. Experiments were conducted to optimize the operating conditions (such as pouring temperature, casting speed and tip setback) for a range of roll gaps for both conventional TRC and melt conditioned MC-TRC using process scrap of alloys AA5754. The Melt Conditioning (shearing) device comprises a rotor and stator assembly and is made from a proprietary ceramic material capable of working in molten aluminium.

Results

1- As Cast AA5754 strips

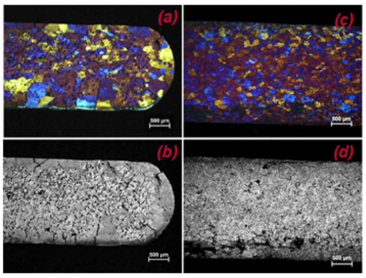


Figure 1. *Optical micrographs of as cast AA5754 alloy: (a&b) Conventional TRC; (c&d) MC-TRC.*

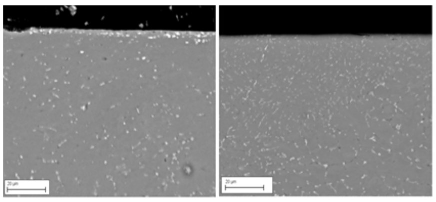


Figure 2. *SEM micrographs of as cast AA5754 alloy showing the distribution of Fe bearing intermetallic: (a)Conventional TRC; (b) MC-TRC.*

2- Cold Rolling with Heat Treatment of AA5754 strips

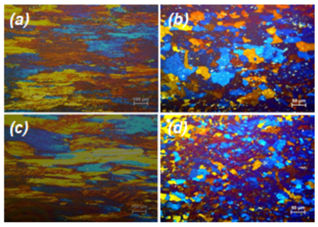


Figure 3. *Optical micrographs of AA5754 strips: (a) Cold rolling of as cast TRC strip; (b) Annealing of deformed cold rolled TRC strip at 430 °C for 30 min.; (c) Cold roll of as cast MC-TRC strip and (d) Annealing of deformed cold rolled MC-TRC strip at 430 °C for 30 min.*

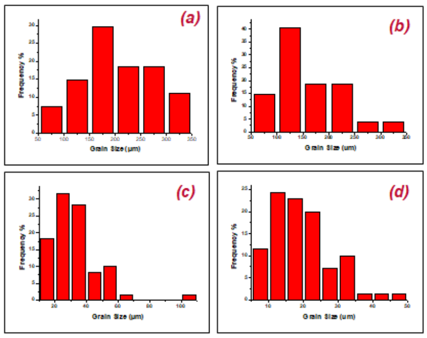


Figure 4. *Grain size distribution of: (a) as cast TRC; (b) as cast MC-TRC; (c) Annealed TRC and (d) Annealing MC-TRC .*

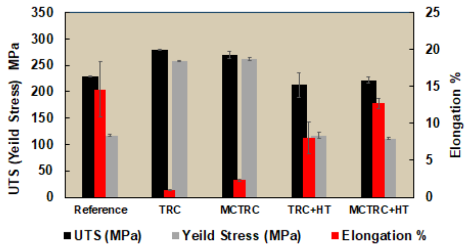


Figure 5. *Effect of thermo-mechanical treatment (cold rolling followed by annealing at 430ºC for 30 min) on mechanical properties of AA5754 alloy.*

Conclusions

- By using liquid intensive melt conditioning, it is possible to influence solidification during Twin Roll Casting, and promote equiaxed growth resulting in improved sheet quality and properties with minimal centre-line segregation.
- MC-TRC AA 5754 strips shows a fine, equiaxed grain structure with reduced or eliminated centre line segregation.
- The thermal treatment of cold rolled AA5754 strips shows a clear grain recrystallization at 430 °C for 30 min.

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